First Exam

- The first exam will be on February 15 at 8am in the lecture room, MacKay 117.
- 20 multiple choice questions each worth 5 points.
- You can bring 1 page of hand written notes (only 1 side of handwritten notes; no photocopies allowed)
- Don't forget to bring a pencil (for the cards).
- NO Calculator is allowed.

Conservation of Mass

- Conservation of mass means

  "In any physical process, mass is neither created nor destroyed"
- This is true in classical physics (but breaks down in relativity)

Momentum

momentum = product of mass x velocity

- mass x velocity which represents the "quantity of motion" is called momentum
- Momentum is a vector quantity; it has both a magnitude and direction

$$P = mv$$

- When we have more than one object we can calculate the total momentum as the sum of the momenta of all objects (remember this is a vector sum)

Restating Newton's First Law

- If no force acts on an object, its velocity does not change hence its momentum does not change.
- Then we can restate Newton's first law in terms of momentum:

  "If no force acts on an object, its momentum does not change"

Restating Newton's Second

- We can thus restate Newton's Second Law:
- "The net force on an object is equal to the rate of change of its momentum"

$$F = m\frac{\Delta(v)}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = \frac{\Delta p}{\Delta t}$$

Conservation of Momentum

$$P = mv$$

- Momentum is conserved: Forces just transfers momentum between the two objects interacting
- This means:
  - In a system where there are no external forces, the momentum of the system is constant

$$P_{\text{initial}} = P_{\text{final}}$$

Recoil

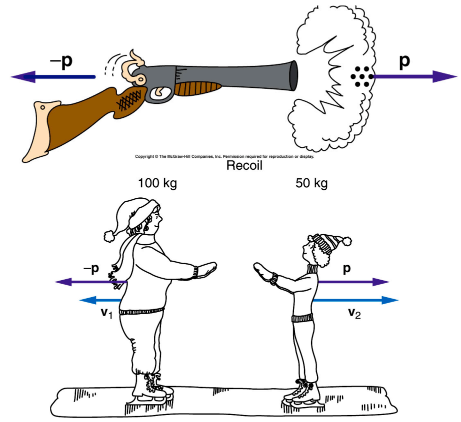
- During recoil, objects push against one another, moving in opposite directions.
- If no external forces are acting on the system, we can use conservation of momentum to calculate recoil velocity
- Since the two are initially at rest

$$P_{\text{initial}} = 0$$

- Therefore the momentum conservation equation is

$$P_{\text{initial}} = P_{\text{final}} = 0$$

Examples of recoil

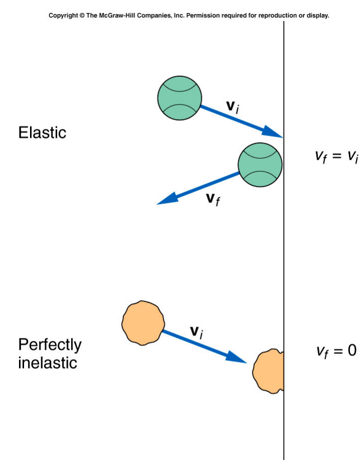


Collisions

- A collision is an event where two objects exchange momentum by acting on each other with a force for a period of time.
- There are two kinds of collisions:
  - Elastic: The objects have the same relative speed before and after the collision
  - Inelastic: The objects relative speed is reduced during the collision
- Using Conservation laws, we can often analyze collisions without knowing the details of the forces involved. Just the total momentum transferred: impulse

Examples of collisions

- A collision is elastic if no energy is lost
- A collision is partially inelastic if some energy is lost but object do not stick together
- A collision is perfectly inelastic when object stick together.



Elastic Collisions

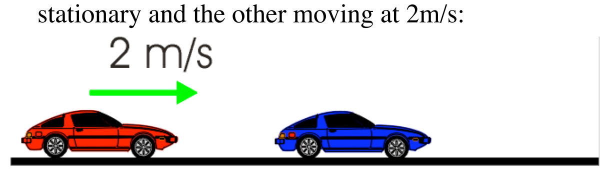
- During the course of an elastic collision, none of the initial kinetic energy present in the system is lost (ie. converted into another form of energy)

$$\boxed{K_f = K_i}$$

- The relative velocity of the two objects is the same before and after the collision
- As in any collision, total momentum is conserved

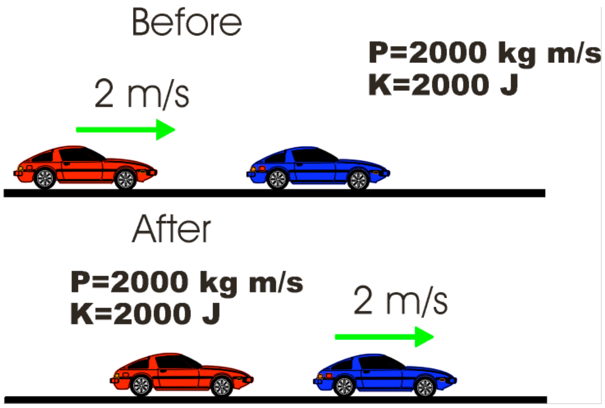
Elastic Collision Example

- Consider two identical cars of mass 1000kg one stationary and the other moving at 2m/s:



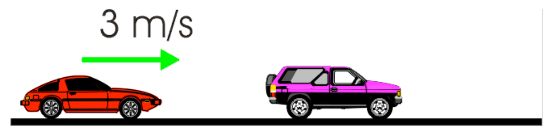
- If the bumpers work properly and the collision is elastic, what happens?

Elastic Collisions (cont.)



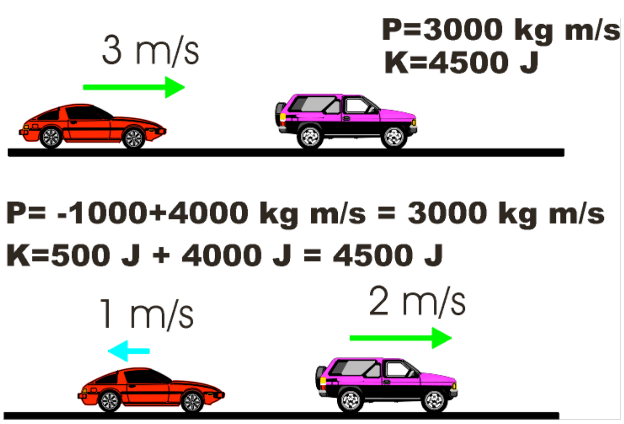
Elastic Collisions (cont.)

- Now consider a 1000kg car going at 3m/s hitting a stationary 2000kg truck.



- Suppose the collision is elastic

Elastic Collisions (cont.)



Inelastic Collisions

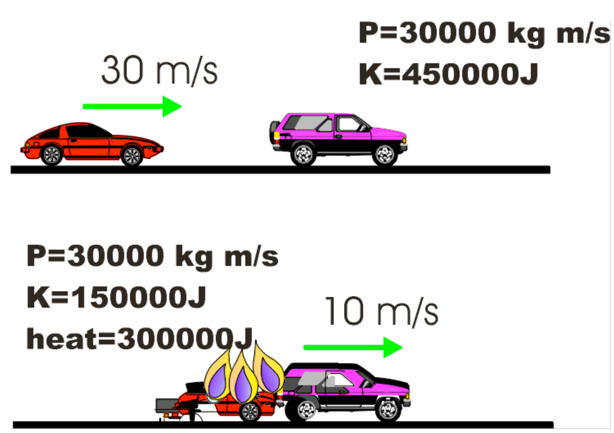
- During an inelastic collision, some of the initial kinetic energy is converted into some other form of energy, often heat. $K_f < K_i$
- After the collision, the relative velocity of the two object has been reduced
- As in any collision, total momentum is conserved.
- In a maximally inelastic collision, the two objects have zero relative velocity after the collision. For example they are stuck together.

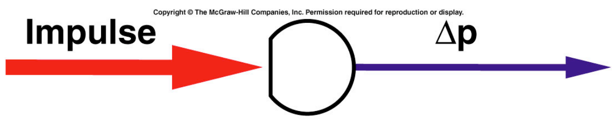
Inelastic Collision Example

- Consider a car of mass 1000kg moving at 30m/s colliding with a truck of mass 2000kg which is stationary.

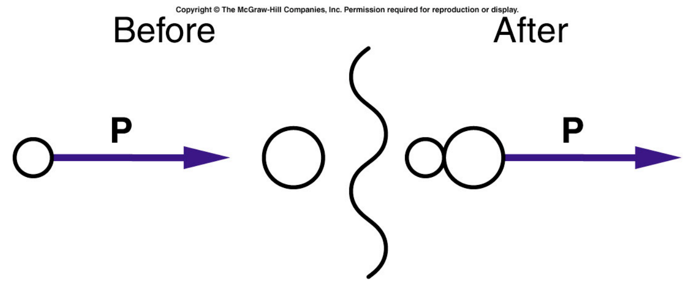
- In this case let us assume that the cars destroyed and move together

Inelastic Collision (cont.)





$\mathbf{F}\Delta t = \Delta\mathbf{p}, \qquad \mathbf{p} = m\mathbf{v}$



If $\mathbf{F}_{\text{external}} = 0$

$\mathbf{P}_{\text{total}} = \text{constant}$